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Performance Analysis of Flower Pollination Algorithm Based Controllers in AGC of Multi Area Power System

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Abstract: This article presents the design and analysis of two degree of freedom (2DOF) controller with integral plus double derivative (2DOF-IDD) and with proportion plus integral plus derivative (2DOF-PID) controller for Automatic generation control (AGC) of multi area power systems with two thermal and two wind system using Flower pollination algorithm (FPA). Secondary controller gains and other parameters are simultaneously optimized using most recent technique called FPA. The system dynamics responses obtained with 2DOF-IDD controller are compared with that obtained from other 2DOF controllers like 2DOF-PI and 2DOF-PID controller. Investigation shows that 2DOF-PI and 2DOF-PID give nearly same response but 2DOF-IDD gives much better response than other two controllers.

Keywords: Automatic generation control; Two degree of freedom controller; Flower pollination algorithm; Integral plus double derivative

I. INTRODUCTION

In large scale power system Automatic generation control (AGC) plays an important role. Due to the dynamic nature of load, it is necessary to maintain the balance between generation and load demand .There by improving the performance of the generating unit the frequency and tie line power should be maintained in prescribed limit is known as Automatic generation control (AGC) [1]. Many researchers have been applied many secondary controllers in automatic generation control (AGC) system such as 2DOF controllers [2,3], classical controllers PI, PID [4,5] Sliding mode controller (SMC) [6,7] and fuzzy logic controller [8,9]. Many intelligence technique like Differential evolution(DE), Cuckoo search algorithm, Teaching learning based optimization (TLBO) [10,11], Bat algorithm, Flower pollination algorithm(FPA) andhybrid PSO-PS have been applied to optimize the gains and parameters of the controllers [12]. The vital objectives of the present work are:

a) Optimization of the controller gains of 2DOF controllers such as 2DOF-PI, 2DOF-PID and 2DOF-IDD controller in a two area wind thermal system using FPA.
b) Comparing the dynamic response obtained with FPA, Genetic algorithm (GA).
c) System investigated.

The system model consist of two equal area having capacity 2000MW each. Both areas has one reheat type thermal system and wind system in which thermal participate 80% and wind participate 20%. Controllers such as 2DOF-PI, 2DOF-PID and 2DOF-IDD have taken separately in the system. Dynamic characteristics are considered by taking step load perturbation (SLP) 2% in area-1.Simulation has been done in Matlab/SIMULINK environment. Matlab Simulink model is shown in Figure 1. The main objective of ALFC loop is to minimize the frequency and tie line power deviation with different load perturbation.

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Nomenclature and Values of the Parameters

Ri - Regulation of governor = 2.4 Hz/ pu MW
β_i - Frequency bias parameter = 0.425
T_{gi} - Time constant of the governor = 0.08 sec
K_{ri} - Gain of the re-heater = 0.3
T_{ri} - Time constant of the re-heater = 10 sec
T_{ti} - Time constant of turbine = 0.3
T_{P1} - Time constant of hydraulic pitch actuator = 0.041
K_{p1} - Gain of hydraulic pitch actuator = 1.25
T_{p2} - Time constant of hydraulic governor = 0.6
K_4 - Gain of data fit pitch response = 1.40
K_{Psi} - Power system gain = 120
T_{Psi} - Time constant of power system = 20 sec
ΔP_D - Step load perturbation = 0.01 pu

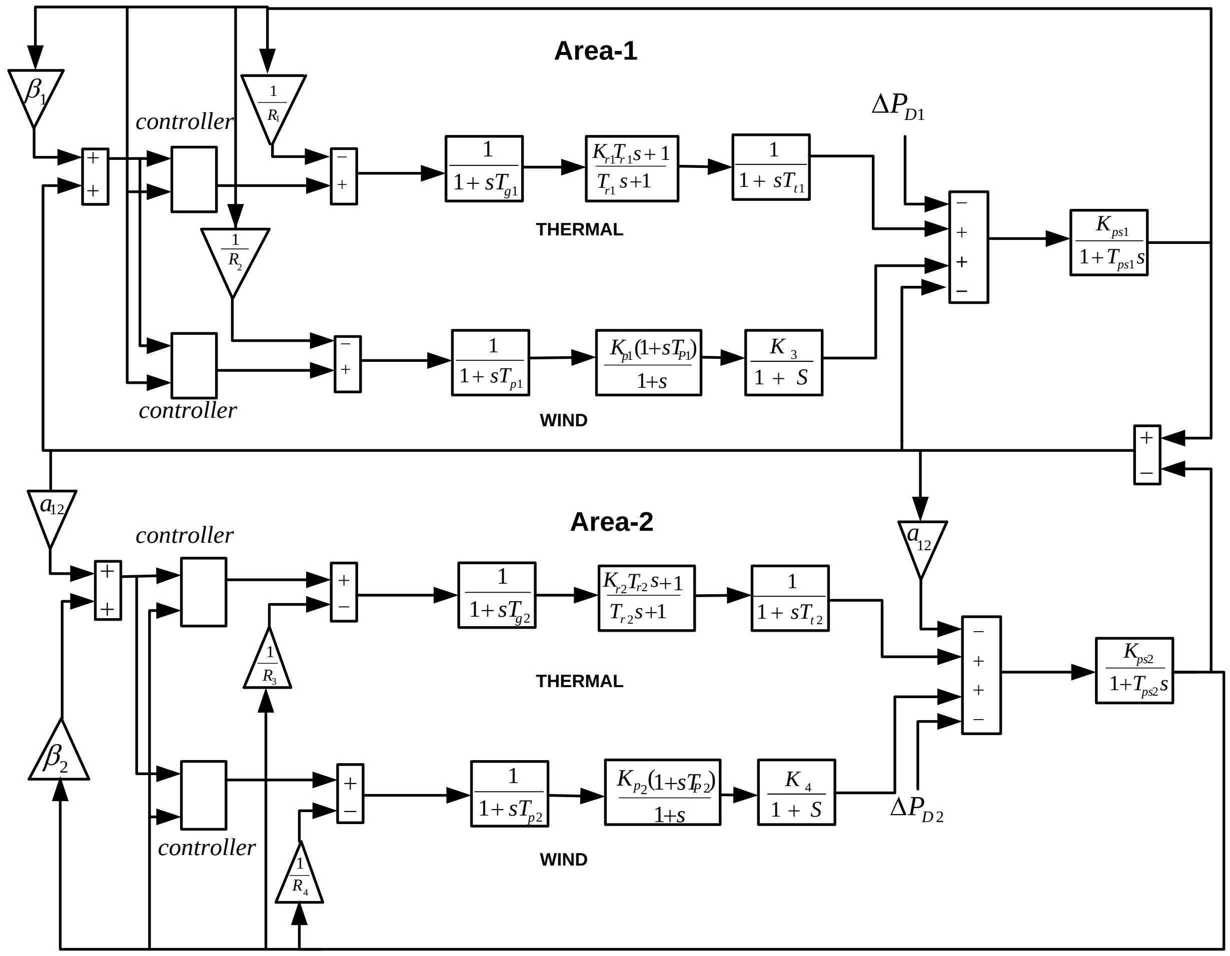

Figure 1: Two area thermal wind system.

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II. TWO DEGREE OF FREEDOM (2DOF) CONTROLLER

In this paper 2DOF controller is used as secondary controller in the system which minimizes the frequency and tie line power deviation with different power demands. Two degree of freedom controller differs from single degree of freedom controller in many aspects. 2DOF controller has two inputs whereas single degree of freedom controller has single input with weighting factors such as. Degree of freedom is defined as number of closed loop transfer function handled independently. Controller produces output as reference to the difference between reference signal and output. Structure of 2DOFPID controller is shown in Figure 2.

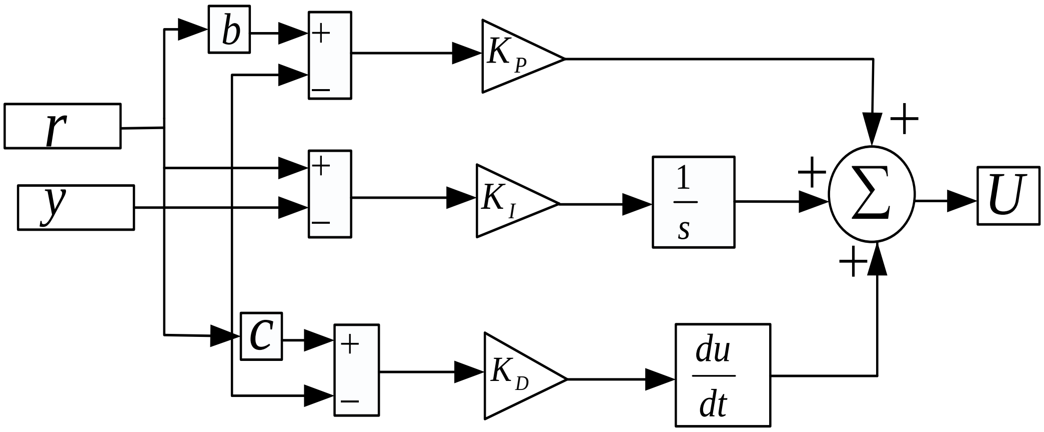

Figure 2: 2DOFPID controller.

III. FITNESS FUNCTION

The purpose of the Fitness function is to find the best parameters of controller which minimizes the frequency deviation. Here we use Integral of time multiplied absolute error (ITAE) as a fitness function.

$$ITAE = \int_0^T \left(|\Delta f_i| + |\Delta P_{tie}|\right)dt \quad (1)$$

IV. FLOWER POLLINATION ALGORITHM (FPA)

Objective function min $[f(x)]$, $x=[x_1, x_2 \ldots x_n]$
Initialize the random solution vectors of n pollen gametes
Search the best solution x_{best} in the initial population
Set the switch probability, $P \in [0, 1]$
While *(t < maximum generation)*
For $i = 1: n$
If r and $< P$
Draw a (d-dimensional) step vector L which obey Levy's distribution
Global pollination $x_i^{t+1} = x_i^t + L\,(x_{best} - x_i^t)$
Else
Choose∈from a uniform [0, 1]
Randomly choose p and q from all the solution
Local pollination $x_i^{t+1} = x_i^t + \in (x_p^t - x_q^t)$
End if
Find new solution if new solution is better then update it
End for
Find the current best solution x_best
End while

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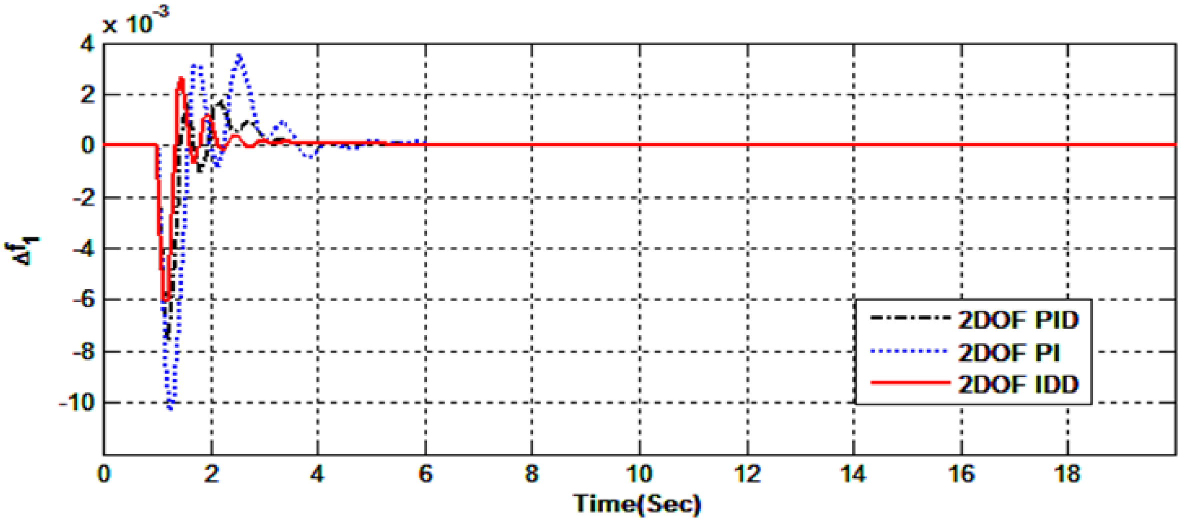
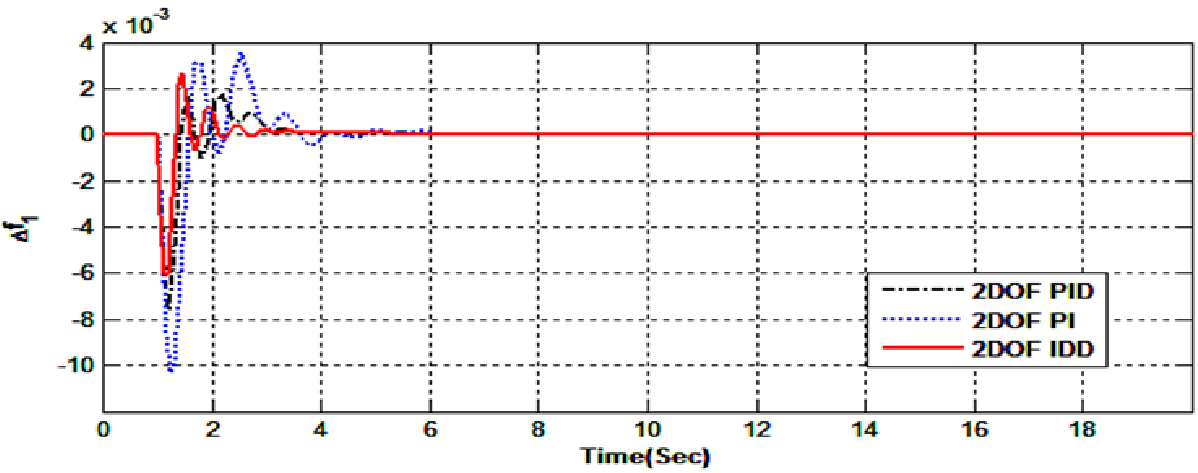
V. RESULTS AND DISCUSSION

Frequency variation of area-1 and area-2 is plotted with different intelligence technique and with different 2DOF controllers which shows the superiority of FPA based 2DOF-IDD controller (Figure 3).



(a)



(b)

Figure 3: Frequency deviation of (a) area-1 and (b) area-2 with different controllers having 2% step load perturbation in area-1.

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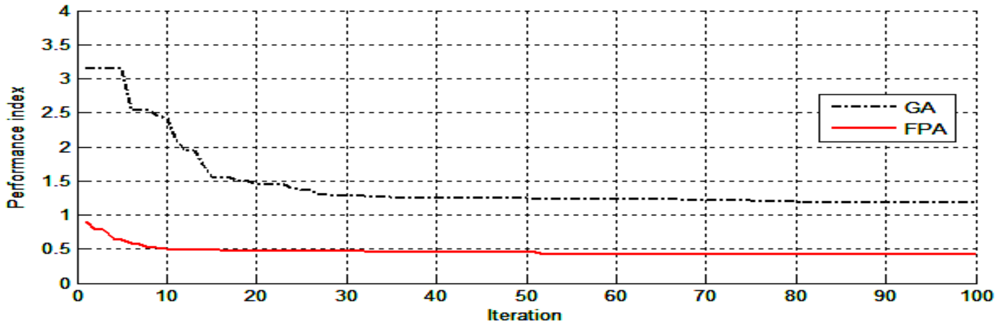
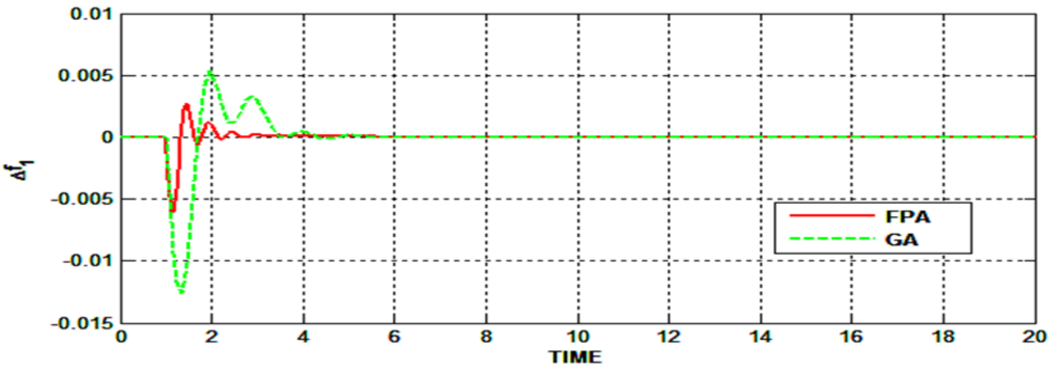
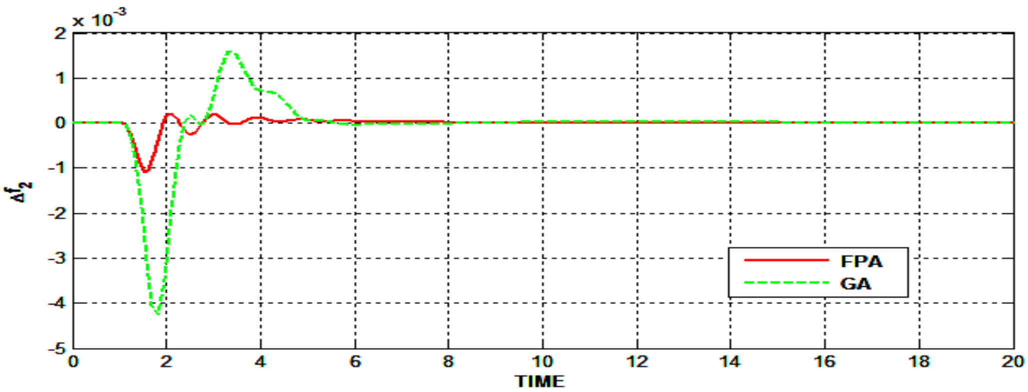


(a)



(b)



(c)

Figure 4: (a) Convergence curve (b) Frequency deviation of area-1 (c) Frequency deviation of area-2.

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From Figure 3 it can be shown that 2DOFIDD controller gives better dynamic response than 2DOFPID and 2DOFPI controller. A new population based optimization technique Flower pollination algorithm (FPA) is used to optimize the parameters of the all 2DOF controllers.
Then two meta-heuristic called GA and FPA are compared in Figure 4 which shows the superiority of the FPA technique over GA.

VI. CONCLUSION

Two area four units thermal-wind system has been taken into consideration for the analysis of AGC system. Dynamic analysis has been carried out by giving 2% step load perturbation in area-1 with different secondary controllers such as 2DOF-PI, 2DOF-PID and 2DOF-IDD controllers which reveals the superior performance of 2 DOF-IDD controller. Controller gains are simultaneously optimized with different meta-heuristic optimization techniques like FPA and GA which unveils the superior performance of FPA.

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